DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF STANDARDS
S. W. STRATTON, Director

# REMARKS ON THE QUARTZ COMPENSATING POLARISCOPE WITH ADJUSTABLE SENSIBILITY

BY

FREDERICK BATES
*Bureau of Standards*

[JUNE 2, 1908]

REPRINT NO. 98
(FROM BULLETIN OF THE BUREAU OF STANDARDS, VOL. 5, NO. 1)

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

DEPARTMENT OF COMMERCE AND LABOR

BUREAU OF STANDARDS

S. W. STRATTON, Director

# REMARKS ON THE QUARTZ COMPENSATING POLARISCOPE WITH ADJUSTABLE SENSIBILITY

BY

FREDERICK BATES

*Bureau of Standards*

[JUNE 2, 1908]

REPRINT NO. 98

(FROM BULLETIN OF THE BUREAU OF STANDARDS, VOL. 5, NO. 2)

WASHINGTON

GOVERNMENT PRINTING OFFICE

1908

# REMARKS ON THE QUARTZ COMPENSATING POLARISCOPE WITH ADJUSTABLE SENSIBILITY.

By Frederick Bates.

In an article on a "Quartz Compensating Polariscope with Adjustable Sensibility," which appeared in the Bulletin of the Bureau of Standards (Vol. IV pp. 461–466), the writer discussed the effect on the zero reading of the scale when the Polarization angle $a$ was varied. In general, the intensities of the light emerging from the large and small nicols of a Lippich polarizing system are unequal. Hence, when the analyzing nicol is set for equal intensity of the halves of the field its position is different from what it would have been had the beams been of equal intensity. The angular difference, $\delta$, between the two positions of the analyzing nicol was obtained from the equation

$$\tan\delta = \pm\frac{\sqrt{K}-1}{\sqrt{K}+1}\tan\frac{a}{2} \tag{3}$$

$$\text{where } K = \frac{A_2}{A_1}$$

and is the ratio of the intensity of the light emerging from the small nicol of the polarizing system to that emerging from the large nicol.

We have for a Lippich system

$$A_2 = f(A_1 \operatorname{Cos}^2 a,\ M) \tag{5}$$

where $A_1 \cos^2 a$ is the intensity of the light from the small nicol, if there has been no other loss than that due to the partial crossing of the large and small nicols. $M$ is the algebraic sum of the effects of all the remaining factors upon which the relative inten-

sities of $A_1$ and $A_2$ depend. These factors are quite numerous. Among them may be mentioned absorption, depolarization, the inclination of the small nicol to the axis of the system, the relative inclination of the faces of the small nicol, the positions of diaphragms, and reflection as the light enters the small nicol. It is evident that $M$ is a constant for a particular instrument, but varies with different polarizing systems. For this reason, and because it is a simple matter for the instrument makers to correct for it, the quantity $M$ was neglected in discussing $\delta$ in the paper referred to above.

In "Bemerkungen zu der vorstehenden Batesschen Arbeit,"[1] Dr. Otto Schönrock calls attention to the fact that the writer has not taken the reflection and absorption in the small nicol into consideration in calculating $\delta$ from (3), inasmuch as the equation

$$A_1 = A_2 \cos^2 a \tag{6}$$

was used to obtain $K$. Schönrock modifies (3) in the following manner:

From the well-known Fresnel equations, when light at perpendicular incidence passes from one refracting medium into a differently refracting medium, the fraction

$$B = \left[\frac{n-1}{n+1}\right]^2 \tag{7}$$

is reflected. Applying (7) to the case of air and Iceland spar, where $n = 1.486$, and neglecting (6), Schönrock finds that

$$A_2 = A_1\left[1 - \left(\frac{n-1}{n+1}\right)^2\right]^2 \tag{8}$$

$$= A_1\ 0.925 \tag{9}$$

There is therefore a loss of 7.5% by reflection at the faces of the small nicol. A further allowance of 0.005 was arbitrarily made for the loss due to absorption in the small nicol. Thus, he finds, by considering the losses due to the crossing of the large and small nicols and to reflection and absorption, that

[1] Zs. Ver. Zuckerind, Feb., 1908, p. 111.

$$A_2 = 0.92\ A_1 \cos^2 a \tag{10}$$

and

$$\tan\delta = \frac{1-\sqrt{0.92}\cos a}{1+\sqrt{0.92}\cos a}\tan\frac{a}{2} \tag{11}$$

In Table I is shown a comparison of the values of $\delta$ given by (3) and (11).

TABLE I.

| $a$ | $\delta$ IN SUGAR DEGREES. | |
|---|---|---|
| | From Equation (3). | From Equation (11). |
| 5° | 0.014 | 0.164 |
| 10° | 0.111 | 0.412 |
| 15° | 0.378 | 0.830 |

The values from (11) are markedly larger than those from (3). It is to be remembered that (11) takes into consideration the effect on $\delta$ of the loss in intensity due to reflection and absorption in the small nicol, but neglects all the other factors of $f(M)$. It will be observed for any value of $\delta$ that the value from (11) equals the value from (3) increased by $0.03a$.

Hence,

$$\delta = \tan^{-1}\left[\pm\frac{\sqrt{K}-1}{\sqrt{K}+1}\tan\frac{a}{2}\right] + 0.0103a \tag{12}$$

$$= \tan^{-1}\left(\tan^3\frac{a}{2}\right) + 0.0103a \tag{13}$$

Equation (13) holds for all working values of $a$ and is significantly simpler than (11). A consideration of the remaining factors involved in $f(M)$ would result in decreasing the constant, 0.0103 (=0.03 for $\delta$ in sugar degrees). It is thus evident that if $f(M)$ be taken into account the only effect on the value of $\delta$ given by (3) is to change it by $\pm Ca$ where $C$ is a constant for each individual Lippich system.